Bacterial Recovery from Breast Skin of Genetically Feathered and Featherless Broiler Carcasses Immediately Following Scalding and Picking

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ABSTRACT Genetically feathered and featherless sibling broilers selected for matched BW were killed, scalded, and defeathered to determine the consequences of feathers and empty feather follicles on the recovery of bacteria from carcass breast skin. In trial 1, the vents of all carcasses were plugged and sutured before scalding to prevent the expulsion of cloacal contents during picking. In trial 2, half of the carcasses had their vents plugged and sutured. Immediately after defeathering, breast skin was aseptically removed, and bacteria associated with it were enumerated. In trial 1, the levels of bacteria recovered did not differ between feathered and featherless carcasses: *Campylobacter* $\log_{10}$ 1.4 cfu/mL of rinse, coliform $\log_{10}$ 1.8, *Escherichia coli* $\log_{10}$ 1.6, and total aerobic bacteria $\log_{10}$ 3.1. In trial 2, the carcasses that had vents plugged and sutured had lower levels of all four types of bacteria (differences of *Campylobacter* $\log_{10}$ 0.7 cfu/mL, coliform $\log_{10}$ 1.8, *E. coli* $\log_{10}$ 1.7, and total aerobic bacteria $\log_{10}$ 0.5) than those carcasses with open vents. The lower levels of bacteria recovered from carcasses with the vents plugged and sutured during picking enabled detection of small but significant differences between feathered and featherless carcasses. The level of coliform and *E. coli* recovered was slightly higher by $\log_{10}$ 0.7 cfu for feathered carcasses, but featherless carcasses had marginally higher levels of total aerobic bacteria by $\log_{10}$ 0.4 cfu. Feathered and featherless carcasses with open vents during picking did not differ in the levels of recovery of coliform, *E. coli*, and total aerobic bacteria from breast skin.

(*Key words*: bacteria, breast skin, broiler, defeathering, scaleless)

2003 Poultry Science 82:1641–1647

INTRODUCTION

Bacterial contamination of the external surface of processed poultry carcasses can originate from contact with ingesta or feces excreted from the alimentary tract during growout, transportation, or processing (Oosterom et al., 1983; Genigeorgis et al., 1986; Izat et al., 1988; Hargis et al., 1995; Stern et al., 1995; Byrd et al., 1998; Berrang et al., 2002). Empty feather follicles are said to harbor bacteria, making complete removal of bacteria difficult if not impossible (National Advisory Committee on Microbiological Criteria for Food, 1997), but the impact that feathers and feather follicles have on skin bacteria levels are mainly speculation and have not been properly investigated. *Campylobacter* bacteria have been found in scrapings at the base of empty feather follicles (from the hypodermis) after chilling of broiler carcasses (Berndtson et al., 1992), but samples were taken only after chilling and therefore did not demonstrate that the bacteria entered the follicles during defeathering or migrated under the skin in chilling water. Numbers of *Campylobacter* recovered were $\log_{10}$ 1.4 cfu/mL from the scraping of a 4-cm^2 piece of skin or about the same numbers of *Campylobacter* recovered from swabs of the same size area ($\log_{10}$ 2.1 cfu) on the external surface of neck skin but less than stomached neck skin samples ($\log_{10}$ 3 cfu/g). Therefore, the number of bacteria within feather follicles may not contribute significantly to the total numbers of *Campylobacter* on carcass skin.

Confocal scanning laser microscopy showed *Salmonella* bacteria floating freely inside empty feather follicles on breast skin pieces from freshly defeathered carcasses (Kim et al., 1996), but that was after skin pieces were soaked for 2 h in a cell suspension of *S. Typhimurium* containing 10^9 cfu/mL. Broiler carcasses are typically scalded for 2 to 3 min in water reported to contain about 13 cfu of salmonellae per 100 mL, on the occasions when salmonellae are present (Humphrey and Lanning, 1987; Cason et al., 2000). So the skin pieces and empty feather follicles in the study by Kim et al. (1996) were immersed for 40 to 60 times longer in a *Salmonella* suspension about 10^{10} times more concentrated than what has been reported to occur under typical scalding conditions.

Barnes et al. (1973) pointed out that maceration of poultry skin samples yields higher numbers of bacteria than other sampling techniques. These authors speculate that the higher recovery was "probably due to the bacteria growing down in the feather follicles rather than at the

Received for publication December 24, 2002.
Accepted for publication May 20, 2003.
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surface of the skin." Similar reasoning was offered by Avens and Miller (1973) to explain the fact that "bacteria just beneath the skin surface layer" or "subcutaneous bacteria" were detected when turkey skin was blended after superficial skin decontamination with phenol, ethyl alcohol, and sodium hypochlorite. Release of attached and partially protected bacteria from the skin surface that would not otherwise be captured in a rinsed or stomached sample, but would be released upon blending the skin, is another possible reason for these increases, rather than escape of bacteria imbedded in empty feather follicles.

There are no published reports that have located bacteria within an empty feather follicle immediately following defeathering (scalding and picking), and we have yet to find *Salmonella* or *Campylobacter* within feather follicles of skin samples collected from positive carcasses immediately after defeathering (R. J. Buhr, unpublished data, n > 36 carcasses). Although broiler carcasses with feces-soiled feathers and skin had higher levels of coliform and *Escherichia coli* than carcasses with clean feathers prior to scalding and picking, after defeathering all carcasses had lower levels of these bacteria, and the levels no longer differed between the dirty and clean carcasses (Kotula and Pandya, 1995; Buhr et al., 2000). Therefore, broilers may enter the processing plant with gross contamination with feces and bacteria on skin, feet, and feather surfaces, but the level of bacteria typically decreases substantially as the carcasses progress through processing stages (Oosterom et al., 1983; Lillard, 1989, 1990; Berrang and Dickens, 2000). The current study was undertaken to determine if the presence of feathers and the subsequent empty follicles play a major role in bacterial recovery from processed broiler carcass breast skin immediately following defeathering. To make a comparison between skin with and without feathers, we utilized the genetic featherless line of chickens known as scaleless, which have no feathers on the breast and therefore no follicles before or after processing.

MATERIALS AND METHODS

Propagation of Feathered and Featherless Broilers

Featherlessness in the scaleless lines is the result of an autosomal recessive gene that spontaneously arose in a commercial New Hampshire meat-type chicken strain first described by Abbott and Asmundson in 1957. The featherless condition results from the failure by the ectoderm to transcribe the genes for fibroblast growth factors FGF-2 and FGFR-1 (Song and Sawyer, 1996), the growth factors necessary for formation of ectoderm derivatives, such as feathers, spurs, and scales. Scaleless low-line hatching eggs were obtained from the University of California-Davis in December 1999 (UC-Davis). Body weight of the scaleless low-line hens at 18 wk of age averaged 1.3 kg and 1.5 kg for roosters. To obtain feathered and featherless broilers of comparable BW at the time of processing, roosters from this hatch were mated via artificial insemination to a commercial strain of broiler breeder hens.[3] Chicks from this mating were all heterozygous for the scaleless gene (+/sc) and were raised to maturity. This feathered hybrid line was intermated and produced sibling chicks in an approximate ratio of three-fourths feathered and one-fourth featherless. From these chicks, selected featherless roosters (high BW and large chest circumference) were mated back to their parental hens to produce the chicks used in these two trials. This mating produced sibling chicks that were feathered or featherless in approximately a 50:50 ratio that were selected for comparable BW when processed at 8 and 9 wk of age.

Housing and Campylobacter Challenge

Chicks were hatched and raised on pine shavings in a controlled-environment-type house (5 × 8 m) under simulated commercial management procedures. They were provided a medicated, corn-soybean-meal-based starter (3,100 kcal ME/kg, 23% CP) and a nonmedicated pelleted grower diet (3,200 kcal ME/kg, 21% CP) ad libitum. At 6 wk of age, broilers were leg-banded and weighed, and BW was recorded. For each trial, 1 wk prior to processing, 20 feathered and 20 featherless broilers were selected as matched pairs by BW (pairs were within 25 g and a total BW range of 200 g). Matched pairs were selected to assure feathered and featherless broilers were subjected to similar environmental and mechanical forces during transport and processing through defeathering. The selected broilers were moved into a separate room and confirmed to be *Campylobacter* negative by sampling of fresh fecal droppings. Feces were sampled by pressing a sterile cotton-tipped applicator into several discrete droppings to make a composite sample. Five composite samples were collected, and each swab was placed into an individual vial containing 9 mL of sterile PBS and held on ice until it was cultured on Campy-Cefex agar plates (the absence of *Campylobacter* was confirmed as described in the Bacteria Analysis and Enumeration section).

Five days prior to processing, these broilers were challenged orally with 2 mL of an inoculum containing *Campylobacter jejuni* (10^8 cfu/mL). The evening prior to processing, full-fed broilers were placed into plastic, solid-bottom coops and transported less than 2 km to the pilot processing plant at the research facility. A 12-h feed withdrawal period was chosen to allow minimal retained intestinal content and provide adequate breast skin contact to feces excreted during the cooping period.

Processing Procedures

On the morning of processing, 12 additional feathered broilers (feces were negative for *Campylobacter* and sub-

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[3]Cobb-500, Cobb-Vantress, Siloam Springs, AR.

jected to a 12-h feed withdrawal period) within the same BW range were processed first. This allowed adjustment of the picker to completely remove feathers and the cuticle layer from the breast without excessive "debarking" of the skin over the hips. Broilers were suspended in shackles by their feet and stunned using a brine stunner set at 50 V alternating current (60 Hz) for 12 s. A knife was used to sever both carotid arteries and the right jugular vein, and carcasses were permitted to bleed for 90 s. Broiler carcasses were placed on the processing shackle line and immersion scalded at 55.6°C (132°F) for 90 s in a 2.4-m section of a commercial scalder containing approximately 2,050 L of water. Carcasses were defeathered using a single-pass picker[4] with five banks of picker fingers for 30 s. There was a low-pressure (241 kpa: 35 psi) tap water spray rinse applied to each carcass as they exited the picker and the picker-finger discs were thoroughly cleaned of feathers with hot water (>82.2°C: 180°F) between each batch of four carcasses.

Four broiler carcasses (feathered or featherless) were processed together in one batch on 15.2-cm (6 in) shackle centers. There were eight batches per day, and processing order rotated through the treatment groups twice each day. During the bleeding period prior to scalding, the vents were plugged with cotton tampons[5] and the lips of the vent was sutured[6] closed as depicted in Figure 1 (A and B). This procedure followed the methods described in Berrang et al. (2001), which resulted in the recovery of *Campylobacter* from 100% of nonplugged carcasses and only 11% from plugged and sutured broiler carcasses. Plugging and suturing is the main difference between trials 1 and 2; in trial 1 the vents of all carcasses were plugged and sutured, whereas in trial 2 only half of the carcasses had the vents plugged and sutured. In trial 2, the feathers immediately surrounding the vent (within about 2 cm) were cut with scissors to less than 1 cm in length prior to suturing the vent. Trimming of these feathers enabled tighter closure of the vent by minimizing inclusion of feathers within the suture loops. Trial 2 was conducted on two processing days.

After defeathering, carcasses remained suspended on the shackle line while the entire breast skin from each carcass was aseptically removed with sterile scalpel and forceps as indicated by the gray rectangle depicted in Figure 1 (C and D) and placed into a labeled, sterile plastic bag. This rectangular breast skin sample included the central sternal apterium, sternal feather tracts, and portions of the adjacent pectoral apterium and pectoral feather tracts (Lucas and Stettenheim, 1972). Breast skin was chosen as the sample tissue due to the ability to consistently remove all feathers and the cuticle layer of the skin during picking and because contact between the breast and the environment during growout and transport occurs regardless of carcass weight for both feathered and featherless broilers. Bags containing skin samples were held on ice until bacterial analysis was initiated within 2 h.

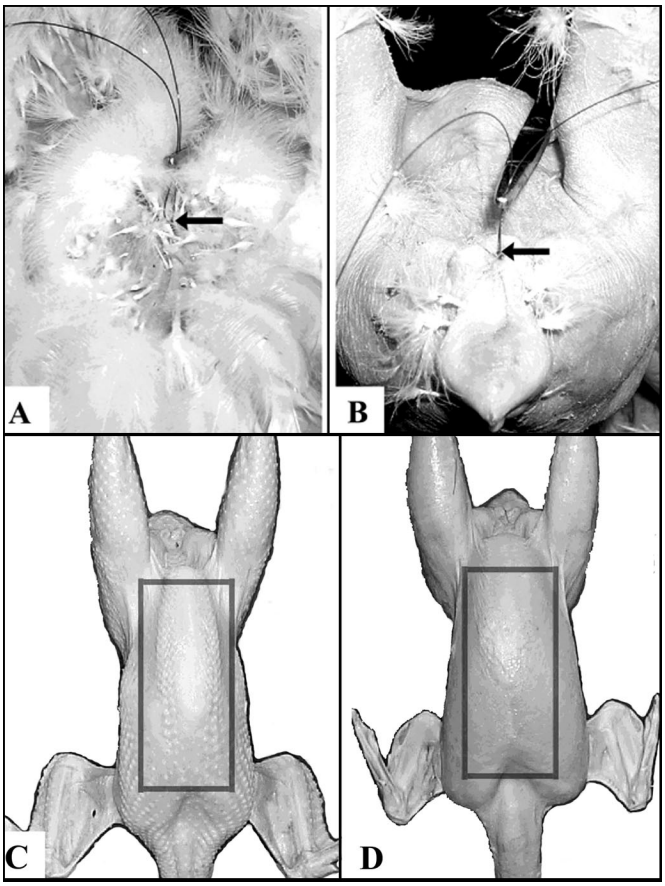

FIGURE 1. View of carcass vent area after plugging and suturing. Arrows indicate where suture material was cut, A) feathered carcass; B) featherless carcass. Rectangular outline of breast skin sample area on carcasses after scalding and picking; C) feathered carcass, note presence of empty feather follicles on breast skin sample area; D) featherless carcass, note absence of feather follicles on breast skin sample area.

Bacterial Analysis and Enumeration

Each skin sample was weighed, three times the weight of the sample of PBS was added and samples were mixed in a Stomacher Lab-Blender[7] for 30 s. Serial dilutions of the rinses were prepared in PBS. *Campylobacter* was enumerated by plating in duplicate onto the surface of Campy-Cefex agar (Stern et al., 1992). One-tenth milliliter was spread on the surface of each plate, after which plates were incubated at 42°C for 48 h in a microaerophilic environment (5% O_2, 10% CO_2, and 85% N_2). Colonies characteristic of *Campylobacter* were counted. Each colony type counted as *Campylobacter* from each sample was confirmed as a member of the genus by examination of cellular morphology and motility on a wet mount under phase-contrast microscopy. Each colony type was further determined to belong to the species *jejuni*, *lari*, or *coli*

[4]Johnson Food Equipment Co., Kansas City, KS.
[5]Proctor and Gamble, Cincinnati, OH.
[6]Ethicon Inc., Somerville, NJ.
[7]Seward Medical, London, UK.

by a positive reaction on a latex agglutination test kit.[8] Coliform and *E. coli* counts were made by plating 1 mL from a serial dilution of the stomached sample onto duplicate *E. coli* Petrifilm plates.[9] Petrifilm plates were incubated at 35°C for 18 to 24 h, and colony types characteristic of coliform and *E. coli* were counted. Total aerobic bacterial populations were enumerated on plate count agar. One-tenth milliliter from a serial dilution was plated in duplicate on the surface of the agar, and incubated at 35°C for 18 to 24 h prior to counting the resulting colony forming units. For trial 1 *Campylobacter*, coliform, *E. coli*, and total aerobic bacteria were enumerated. Trial 2 consisted of two processing days, and on the first day *Campylobacter* was only enumerated and on the second day *Campylobacter*, coliform, *E. coli*, and total aerobic bacteria were enumerated.

Statistical Analysis

Bacterial count data was converted to $\log_{10}$ colony-forming units per milliliter of rinse before conducting an ANOVA analysis using the general linear models procedure of SAS software (SAS Institute, 1994). The sources of variation in the model for main effect were type of carcass (feathered or featherless) and processing batch order (batch 1 to 8) and, in trial 2, treatment (if vents were plugged and sutured or vents remained open). There were 16 feathered and 16 featherless carcasses sampled in each processing day. The bacterial recovery levels are reported only for positive carcasses. For all analyses, significance was determined at $P < 0.05$. The analysis of batch effect (processing order) on each day of processing was not significant ($P > 0.3214$), and therefore batch was deleted from the model and the data reanalyzed. Significant interactions occurred in trial 2 between the plugged and sutured and the open vent treatments for the levels of bacteria recovered. Therefore bacteria recovery levels are presented by treatment for feathered and featherless carcasses for trial 2.

RESULTS AND DISCUSSION

In trial 1, at 8 wk of age, feathered and featherless broilers weighed 1.39 kg, and in trial 2 at 9 wk of age they weighed 1.58 kg on both processing days. These BW are less than half of the values typical for today's commercial broilers at this age (3.9 kg at 8 wk of age) but exceeded those of the "1957" type broilers (0.8 kg at 8 wk of age) during which time the scaleless gene and the featherless lines originated (Abbott and Asmundson, 1957; Havenstein et al., 2002). However, after a single outcross to a commercial broiler strain, matched slaughter BW for feathered and featherless broilers were obtained, and therefore the external and internal forces applied to the paired carcasses during transport and defeathering were assumed to be similar. The breeder and growout flocks of chickens used in these experiments remained *Campylobacter* free as determined by feces sampling. Challenging individual broilers with *Campylobacter* 5 d prior to processing resulted in contamination of both feathered and featherless broilers, as was evident by the recovery of *Campylobacter* from carcass breast skin in both trials.

In trial 1, all feathered and featherless carcasses had similar levels of coliform $\log_{10}$ 1.8 cfu/mL of rinse, *E. coli* $\log_{10}$ 1.6 cfu, and total aerobic bacteria $\log_{10}$ 3.1 cfu when the vents were plugged and sutured (Table 1). The level of *Campylobacter* recovered was also similar at $\log_{10}$ 1.4 cfu, but there was a 19% greater prevalence (number positive carcasses of the total number of carcasses sampled, 4 of 16) for the feathered carcasses than for the featherless carcasses (1 of 16). The recovery of *Campylobacter* from breast skin after scalding and picking may in part be due to leakage of *Campylobacter* from the vent during picking as was proposed by Musgrove et al. (1997) and demonstrated by Berrang et al. (2001). The numerically higher prevalence of *Campylobacter* for feathered carcasses may be attributable to the difficulty encountered in suturing the vent completely closed, while avoiding feathers adjacent to the vent within suture loops, which may have confounded the results. Perhaps, plugging and suturing did not completely prevent leakage of contents from the vent during picking. Berrang et al. (2001) reported an 11% prevalence of *Campylobacter* utilizing the same plugging and suturing procedures with commercial broilers.

In trial 2, carcasses that had the vents plugged and sutured before scalding and defeathering had consistently lowered ($P < 0.05$) bacteria levels (differences of *Campylobacter* $\log_{10}$ 0.8 cfu/mL, coliform $\log_{10}$ 1.8, *E. coli* $\log_{10}$ 1.7, and total aerobic $\log_{10}$ 0.5) than those carcasses that were not plugged and sutured (Table 2). *Campylobacter* was recovered from 28 of 32 carcasses when the vents remained open but from only three of 32 carcasses when the vents were plugged and sutured. The consistently lower levels of *Campylobacter*, coliform, *E. coli*, and total aerobic bacteria recovered from carcasses that were plugged and sutured prior to scalding is strong evidence that cloacal contents are expressed during defeathering recontaminating the carcass, as was described by Berrang et al. (2001) for *Campylobacter*.

For carcasses where the vent remained open, the only difference detected in the level of bacteria recovered from feathered and featherless carcasses was for *Campylobacter*, a $\log_{10}$ 0.8 cfu/mL difference (Table 2). Higher *Campylobacter* levels were recovered from feathered than from featherless carcasses, although, from 2 carcasses of each type *Campylobacter* was not recovered. The presence of empty feather follicles could possibly explain the higher levels of *Campylobacter* recovered from feathered carcasses ($\log_{10}$ 1.9 cfu/mL) than from featherless carcasses ($\log_{10}$ 1.0 cfu/mL). However, the higher level of *Campylobacter* recovered was not associated with higher levels of coliform, *E. coli*, and total aerobic bacteria recovered from feathered carcasses. The prevalence of recovery for coli-

[8]Integrated Diagnostic, Inc., College Park, MD.
[9]3M Health Care, St. Paul, MN.

TABLE 1. Bacterial recovery (log_{10} cfu/mL of rinse) and prevalence from breast skin after scalding and defeathering both featherless and feathered broiler carcasses that had the vents plugged and sutured prior to scalding and picking, trial 1

	Featherless		Feathered	
	Log_{10} cfu/mL	Prevalance	Log_{10} cfu/mL	Prevalance
Campylobacter	1.4	(1/16)[1]	1.5	(4/16)
Coliform	1.8	(16/16)	1.8	(16/16)
Escherichia coli	1.6	(16/16)	1.5	(16/16)
Total aerobes	3.2	(16/16)	3.0	(16/16)
Source of variation				
Featherless vs. feathered				Probability
Campylobacter				0.8387
Coliform				0.8385
E. coli				0.5483
Total aerobic				0.0858

[1]Numbers in parentheses indicate the number of positive carcasses out of a total of sixteen sampled. There were no significant differences in the levels of bacteria recovered between featherless and feathered carcasses ($P > 0.0858$).

form, *E. coli*, and total aerobes was 100% (8 out of 8 carcasses) for both feathered and featherless carcasses where the vent remained open.

In trial 2, for carcasses with plugged and sutured vents, *Campylobacter* was not recovered from any featherless carcasses and from only 3 of 16 feathered carcasses, but at the level of the limit of detection (1 cell per 0.2 mL of rinse or log_{10} 0.7 cfu/mL of rinse). These *Campylobacter*-positive feathered carcasses were detected as a single carcass out of batch of four on the first processing day, and as two adjacent carcasses on the second processing day. However, both batches had been immediately preceded by a batch of featherless carcasses that were all *Campylobacter* negative and the picker cleaned between batches. Both coliform and *E. coli* were recovered at higher levels (log_{10} 0.7 cfu/mL of rinse) from feathered carcasses than from featherless carcasses when the vents were plugged and sutured. The recovery of *Campylobacter* and higher recovery levels of coliform and *E. coli* suggests that leakage of cloacal contents could have occurred in the feathered carcasses despite the trimming of feathers around the vent prior to suturing. However, the possibility that feathers or empty feather follicles were involved in the higher recovery of *Campylobacter*, coliform, and *E. coli* cannot be excluded.

For carcasses that had the vents plugged and sutured prior to defeathering, total aerobic bacteria were recovered at a marginally higher level (log_{10} 0.4 cfu/mL) from featherless carcasses (log_{10} 3.3 cfu) than from feathered carcasses (log_{10} 2.9 cfu; Table 2). When vents remained open during picking, the levels of total aerobic bacteria recovered for both feathered and featherless carcasses were about log_{10} 0.3 cfu/mL higher than when vents were plugged and sutured, and featherless carcasses had nonsignificantly higher (log_{10} 0.3 cfu/mL) levels than feathered carcasses. Total aerobic bacteria are apparently recovered in greater numbers from featherless carcasses than feathered carcasses after scalding and picking. Berrang and Dickens (2000) reported no change in total aerobic bacteria pre- to postpick for carcasses sampled from a commercial processing plant, but significant increases for coliform, *E. coli*, and *Campylobacter*. They suggested that these common gut bacteria (coliform, *E. coli*, and *Campylobacter*) are expressed from the cloaca during picking and recontaminate the carcass. Notermans et al. (1980) reported that fecal contamination during evisceration resulted in significantly elevated levels of *Enterobacteriaceae*, but no increases for total aerobic bacteria. This pattern for featherless carcasses to have slightly higher aerobic bacteria counts than feathered carcasses was also detected by whole carcass rinses after defeathering in other experiments (log_{10} 3.7 cfu/mL of rinse for featherless and log_{10} 3.4 cfu for feathered carcasses; R. J. Buhr, unpublished data). However, whole carcass rinses prior to scalding revealed slightly higher aerobic bacterial counts for feathered carcasses (including the feathers) than for featherless carcasses (log_{10} 5.4 cfu/mL of rinse for feathered and log_{10} 5.0 cfu for featherless carcasses; R. J. Buhr, unpublished data).

The impact of the presence of feathers and subsequent empty feather follicles on the level of bacteria recovered from breast skin after defeathering is not clear, and apparently may differ depending on the level of bacterial contamination, the types of bacteria recovered, and whether the vent is plugged and sutured completely prior to defeathering. For carcasses processed with the vent open, there were no differences in the levels of coliform, *E. coli*, and total aerobes recovered from feathered or featherless carcasses. However, the level of recovery of *Campylobacter* was greater from feathered carcasses (log_{10} 1.9 cfu/mL) than from featherless carcasses (log_{10} 1.1 cfu/mL). For carcasses processed with the vents open, the expression of cloacal contents during picking appears to have elevated the numbers of these bacteria that were recovered from breast skin. These results provide further support for the concept proposed by Berrang et al. (2001) that broiler carcass *Campylobacter* levels are reduced significantly during scalding and it is the expression of cloacal contents (containing *Campylobacter*) during picking that spreads *Campylobacter* onto breast skin recontaminating and cross-contaminating carcasses.

For carcasses processed with the vents plugged and sutured, the impact of the presence of feathers and empty

TABLE 2. Bacterial recovery (log_{10} cfu/mL of rinse) and prevalence from breast skin after scalding and defeathering of both featherless and feathered broiler carcasses that had the vents plugged and sutured prior to scalding and picking, or remained open, trial 2

	Vents plugged and sutured				Vents open			
	Featherless		Feathered		Featherless		Feathered	
	(Log_{10} cfu/mL)				(Log_{10} cfu/mL)			
Campylobacter	0.0	(0/16)[1]	0.7	(3/16)	1.1[b]	(14/16)	1.9[a]	(14/16)
Coliform	1.0[b]	(8/8)	1.7[a]	(8/8)	3.3	(8/8)	3.1	(8/8)
Escherichia coli	0.7[b]	(8/8)	1.4[a]	(8/8)	2.8	(8/8)	2.6	(8/8)
Total aerobes	3.3[a]	(8/8)	2.9[b]	(8/8)	3.8	(8/8)	3.5	(8/8)

Source of variation	Treatment: Plugged vs. vents open	Interaction: Treatment vs. feathered and featherless
	Probability	
Campylobacter	0.0004	ND[2]
Coliform	0.0001	0.0012
E. coli	0.0001	0.0024
Total aerobic	0.0001	0.4135
Feathered vs. featherless	Vents plugged	Vents open
Campylobacter	ND	0.0008
Coliform	0.0017	0.2650
E. coli	0.0039	0.3060
Total aerobic	0.0212	0.1552

[a,b]Within bacteria type, significant difference in the level of bacteria recovered between featherless and feathered carcasses ($P < 0.05$).

[1]Numbers in parentheses indicate the number of positive carcasses (prevalence) out of the total sampled.

[2]Not calculable due to zero recovery for featherless carcasses that were plugged and sutured.

feather follicles on the level of bacteria recovered from breast skin after defeathering is further complicated by the completeness of vent closure after plugging and suturing. The lower levels of recovery of *Campylobacter* in trial 2 compared to trial 1 (for carcasses that had the vents plugged and sutured) suggests a more complete closure of the vents occurred in trial 2. However, the recovery of *Campylobacter* from feathered carcasses in trial 2, although at the lowest level of detection in each case, still suggests that the vents of the feathered carcasses were less impermeable to the expression of cloacal contents than were the vents of the featherless carcasses. The possibility of cloacal leakage is also supported by the higher levels of coliform and *E. coli* recovered from the feathered carcasses.

The role that feathers and empty feather follicles play on carcass skin bacteria levels will continue to be investigated in future experiments. Modifications to the vent plugging and suturing technique will be made to assure impermeability by the absence of recovery of *Campylobacter* from all plugged and sutured carcasses following scalding and picking. These experiments will utilize feathered and featherless carcasses with heavier BW that are the results of two additional outcrosses to commercial broiler breeder lines. In addition, the recovery of *Campylobacter* will include enrichment for the detection of levels < log_{10} 0.7 cfu/mL rinse, and histological evaluation of skin samples will be made to identify and locate bacteria on and within skin samples.

ACKNOWLEDGMENTS

The authors are grateful for the assistance with processing, sample collection, and bacteria enumeration provided by Dianna V. Bourassa, Linda A. Brothers, Mark N. Freeman, L. Kathy Orr, and Lauren G. Pittenger.

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